§3. Improvements of the LHD Cryogenic System for Highly Reliable Operations

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The LHD cryogenic system has operated 67,278 hours with high reliability of 99.1%. However, 14 years have passed from the beginning of the system operation. The improvements are being planned to prevent serious failures and to pursue further reliability. The planned improvements of the LHD cryogenic system are reported.

The failure of the compressors with long MTTR and the failure of the control system with a lot of counts have the majority of the failure cause to the LHD cryogenic system due to stop. Two improvements of the LHD cryogenic system are planned. The first is the addition of redundant compressors. Two kinds of redundant compressors are added to back up even when which one of eight compressors breaks down. The second is the update of the cryogenic control system, in which update the hardware of control system from VME controllers to CompactPCI controllers + remote I/O (EtherNet/IP), while having interchangeability of software

At the 14th cycle operation, the thrust bearing of the screw compressor broke down immediately after the start of the purification. It required 228.4 hours for the repair restoration, and as a result, the availability of 14th cycle has considerably decreased.

The compressor system consists of A-system of inlet pressure 0.1013MPa and B-system of inlet pressure 0.203MPa as shown in Fig. 1. The outlet pressure is 1.935 MPa in both A- and B-systems. A-system is composed of four low pressure compressors and two high pressure compressors. B-system is composed of a low pressure compressor and a high pressure compressor. The eight compressors are not made redundant, and even if which one breaks down, the operation of the cryogenic system cannot be continued. To require a long time to repair when the failure occurs with the compressor, the availability of the system is remarkably decreased.

Two redundant compressors (R-system) both for the low pressure unit and for the high unit have been being added to improve the system reliability further in 2012. The redundant compressors have the specifications to which the connection location can be switched with the valve to back up even if which compressor in low pressure or high pressure and A-system or B-system breaks down. In addition, it is possible to correspond to the operating condition by adjusting the load of the capacity control valve according to the compressor backed up

The LHD cryogenic control system was designed and developed as an open system utilizing latest control equipment at the construction time. However, 17 years have already passed, the generation change of control equipment is advanced, and it comes at time when the system has to be updated.

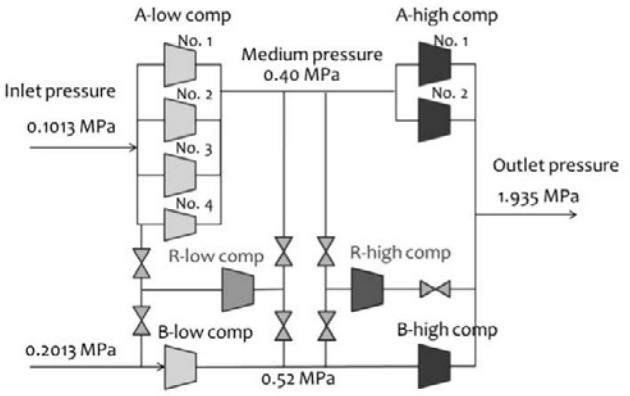

Fig. 1. Addition of the redundant compressors.

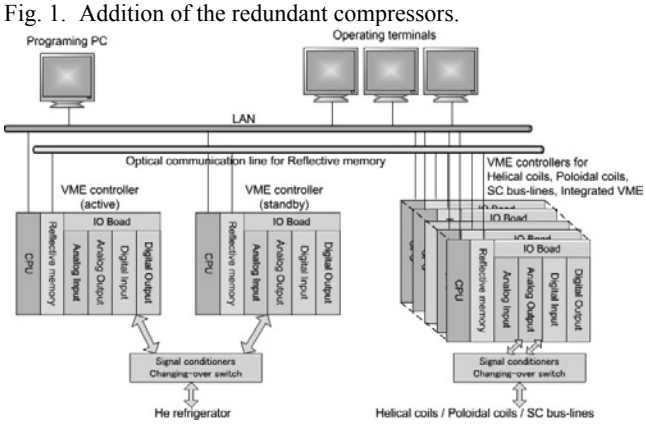

Fig. 2. Existing cryogenic control system.

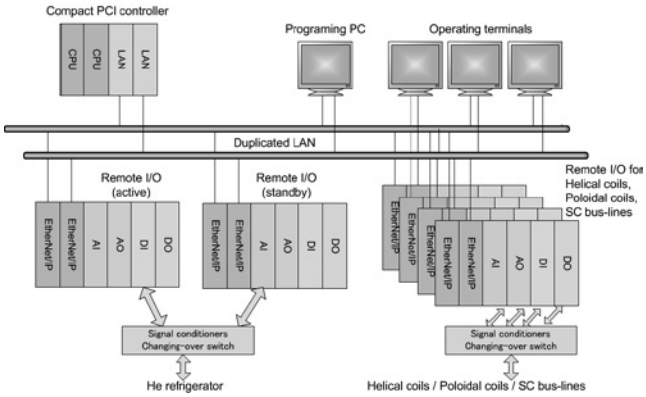

Fig. 3. Updated cryogenic control system.

Fig. 2 shows the existing cryogenic control system. The system consists of 12 VME controllers with AI:1045, AO:216, DI:896, DO: 768, it became too complicated system because of distributed, redundant system with automated fault diagnosis. Down-sizing of control devices is planned from VME controller to compact PCI controller. Fig. 3 shows the updated cryogenic control system. The system is composed of compact PCI controller and remote I/O connected with EtherNet/IP. Making the system redundant corresponds by doubling CPU, LAN, and Remote I/O respectively. Software has interchangeability with the existing system. The constructed various automated programs can be succeeded to the new system easily. The development of the new control system has executed in 2011 fiscal year, the field test starts from 2012 and a complete shift to the new control system is scheduled in 2013.